



**Document Release  
Authorization  
To DOE**



**Los Alamos National Laboratory**

PO Box 1663 MS H816  
Los Alamos, NM 87545

**This is a milestone document:** ☒ **YES** ☐ **NO**

Doc No:

LA-UR-03-xxxx

Release Date:

9/23/03

Title:

Year-End Report on Engineering Contributions to MEGAPIE

Author(s):

Keith A. Woloshun, **Los Alamos National Laboratory**

**Approved for Release**

**Approved by**

**Typed Name**

**Date**

**Signature**

Principal Author:

Keith A. Woloshun

9/23/03

LANL Program Manager:

Michael W. Cappiello

9/23/03



## **Year-End Report on Engineering Contributions to MEGAPIE**

### **Introduction**

MEGAPIE is a liquid-metal (lead-bismuth eutectic) spallation neutron production target project at the Paul Scherrer Institute (PSI), Switzerland. Department of Energy (DOE) engineering support was contributed by Keith Woloshun of Los Alamos National Laboratory, who was stationed on-site at PSI for most of the fiscal year. The general progress of the project during this time was focused toward readiness-for-manufacturing. Extensive review and revision of documents and drawings was the primary activity. Additionally, activity continued in the development of ancillary systems, structural analysis of key components (pumps and heat exchanger), materials issues, and testing of some components, concepts, and subsystems. The specific contribution from DOE is itemized below.

### **Support for Readiness-for-Manufacture Activities**

The readiness-for-manufacture (RFM) process required a detailed review of all drawings and related documents such as thermal and mechanical analysis documentation. For convenience, the target was divided into eight “lots” that could be manufactured independently prior to final assembly. Frequent review meetings were held in which open issues were identified for each lot. A person was assigned responsibility for each open issue for final disposition. In this manner, nearly all lots have been released for manufacture except the main heat exchanger and the central rod (preheaters). The DOE engineer on site participated actively in this RFM process, reviewing the drawings and documents, actively attending the RFM meetings, and contributing observations and open issues.

### **Development of a TRAC System Model**

A RELAP5 system model of MEGAPIE was developed by Ansaldo Nucleare and delivered to PSI. PSI requested an independent TRAC model to verify and reinforce the RELAP model predictions. A complete model was developed over the course of the year. All components and thermal couplings have been checked. The remaining task is proper implementation of the control valve. The strategy of MEGAPIE is to control target temperature using a three-way valve that allows some portion of the cooling oil to bypass the secondary (oil-to-water) heat exchanger. The modelling of this three-way valve with a proportional-integral-derivative (PID) controller is the remaining task to complete the transient reactor analysis code (TRAC) model.

### **DTHT/LBE Interaction Experiments**

One potential failure mode for MEGAPIE is a leak of the cooling oil (DTHT) into the lead-bismuth eutectic (LBE). Such an accident would be detected immediately by



several independent sensors, in particular pressure and level sensors. Nonetheless, the time of contact at elevated temperature could be several hours before the system could be brought to room temperature without active cooling. PSI personnel and the DOE on-site engineer jointly conducted experiments. The objective was to determine if any adverse reactions would occur in the event of this accident that would create high pressures or flammable gases. A report entitled “Experimental Results from DTHT-LBE Interaction Experiments and DTHT Irradiation Tests” documents the results of these experiments, in conjunction with the results of some irradiated DTHT tests. The work was reported at the MEGAPIE Test meeting in Paris, March 2003. The essential conclusion was that there is no instantaneous production of gases at a rate that endangers the facility. A slow increase in pressure was observed due to gases produced by pyrolysis, but the apparent gas production rates were much less than reported by the DTHT vendor. The probable explanation is that hydrogen produced by pyrolysis was absorbed by the DTHT.

### **Reliability Study**

A system-wide reliability study of the MEGAPIE target and ancillary systems is in progress by the DOE engineer. Reliability can be measured, for example as a MTBF (mean time before failure), but this can only be applied in the case in which a significant number of parts have been made and tested to failure. In the case of MEGAPIE, one is faced not only with a first-of-its-kind piece of hardware in the integral sense, but also with the fact that most of the components are also first-of-its-kind, or at least incorporate nonstandard design features and are used under conditions with little or no precedent and limited test data prior to final assembly and integral testing. To assess the reliability of MEGAPIE, a failure mode assessment is made and mitigations identified. Mitigations include literature data, data from MEGAPIE-specific tests (including the integral tests), analysis, and, where available, manufacturer information. While it may not be possible to reduce MEGAPIE to an overall product reliability number, it is a worthwhile goal to assess reliability as far as is pragmatically possible. This allows one to identify the strengths and weaknesses so effective mitigations can be implemented in the time available, thus allowing effective control and response sequences to be implemented to minimize the negative impact of the failure of any higher risk component and decisions to be made about the readiness for irradiation, under what conditions and for what duration. This study is conducted on the component and subsystem breakdown structure used for design and manufacture. The main target is divided into eight lots, plus the EMP/EMFM system. Each ancillary system is also evaluated.

The reliability study is a work in progress, currently in the form of a 30-page report itemizing 25 issues in which either reliability is a real concern or the evidence is not sufficient to ascertain component reliability. In either case, it is incumbent upon the DOE engineer to work with project specialists to resolve issues and improve reliability as far as practical. The critical issues and components at this time are the LBE pump/flow meter assembly, certain aspects of the primary heat exchanger, window material life issues, and the LBE leak detector system.



### **Heater Selection and Testing for the Integral Tests**

In collaboration with PSI personnel, the DOE engineer worked to prepare heaters for simulated beam heating tests as a subset of the overall integral test plan. The goal is to deliver enough thermal power by resistance heating to test system thermal performance during steady state and transients. A bank of 19 heaters will be used to provide 175 kW to the target. Heaters were selected and some preliminary tests in LBE were performed. A test station for longer-term tests has been designed. The test section is now in fabrication.